The President read a letter addressed to him by the Baron de Bonstettin, containing inquiries respecting ancient pipes discovered in excavations in Ireland.

The following antiquities were presented to the Museum:—

1. An iron spear-head found in the county of Fermanagh. Presented by Miss Richardson.

2. A small cinerary urn, found near Cabinteely, on the land of the donor. It was discovered in the centre of a small chamber filled with a mixture of clay and bone-dust, and covered with a large flag, and about two feet of earth. Presented by J. H. Jessop, Esq.

3. A small glass bottle, found in Ardglass, county of Down. Presented by Rev. J. H. Todd, D. D., President.

4. Five modern Indian coins, and a small ingot of silver. Presented by William Kennedy, Esq.

5. Several copies of the new Index to the Ordnance Map of Ireland, on the scale of one inch to the statute mile, showing the state of publication on the 30th of November, 1857. Presented by Captain Leach.

MONDAY, JANUARY 11, 1858.

HUMPHREY LLOYD, D.D., Vice-President, in the Chair.

ALEXANDER T. BLAKELEY, Esq.; Maurice Henry Collis, M.B.; Howard B. Montgomery, M.D.; and John Purser, Jun., Esq.; were elected Members of the Academy.

The REV. DR. LLOYD read a paper—

ON THE DETERMINATION OF THE INTENSITY OF THE EARTH'S MAGNETIC FORCE IN ABSOLUTE MEASURE, BY MEANS OF THE DIP CIRCLE.

THE received method of determining the intensity of the earth's magnetic force is unsuited to the high magnetic latitudes, the error of the deduced force, arising from a given error of inclination, becoming very considerable when the latter approaches to 90°. To remedy this defect the author suggested, some years since,* another process, in which the total intensity is found *directly* by means of the dip circle,—the *product* of the earth's magnetic force into the magnetic moment of the magnet being determined by the position of equilibrium of the dipping-needle, when loaded with a small weight, and the *ratio* of the same quantities being found by removing the needle, and employing it to deflect another substituted in its place. Subsequent considerations, however, led him to propose that the dip-circle should be employed only in the *latter* part of the process, and that the observation should be completed by the known method.

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* See "Proceedings," January 24, 1848.

In the present communication the author shows in what manner this complication may be avoided, and the original proposal carried out. It is of great importance to the scientific traveller that the instruments which he has to carry should be reduced, as far as possible, in number and weight, and that their adjustments should be few and simple; and these objects, it is believed, will be attained by the use of the method now proposed.

The equation of equilibrium of a dipping-needle, when loaded with a small weight acting in opposition to magnetism, is

$$M(Y \cos \eta - X \cos \alpha \sin \eta) = Wr; \tag{1}$$

in which X and Y denote the horizontal and vertical components of the earth's magnetic force, M the magnetic moment of the needle, α the magnetic azimuth of the plane in which it moves, η its inclination to the horizon, W the added weight, and r the radius of the pulley by which it acts. And when this needle is removed, and applied to deflect another substituted in its place, the equation of equilibrium of the latter is

$$Y \cos \eta' - X \cos \alpha' \sin \eta' = MU; \tag{2}$$

α' and η' denoting, as before, the azimuth and inclination of the needle, and U being a function of the distance of the centres of the two needles, and of certain integrals depending on the distribution of free magnetism in them.

When the planes in which the needles move coincide with the magnetic meridian, or $\alpha = 0$, $\alpha' = 0$, the left-hand members of these equations are reduced respectively to $MR \sin(\theta - \eta)$, $R \sin(\theta - \eta')$; R denoting the total force, and θ the inclination. Wherefore, multiplying, we have

$$R^2 \sin(\theta - \eta) \sin(\theta - \eta') = UWr; \tag{3}$$

an equation which gives the force, R, in terms of the observed angles, θ, η, and η', and of the quantities U, W, and r.

But the angles, θ, η, and η', are liable to error, arising from the friction of the needles on their supports; and the corresponding error of the deduced force varies inversely as the sine of the angle of deflection, $\theta - \eta$, or $\theta - \eta'$. It is, therefore, requisite for accuracy that these angles should be considerable. There is no difficulty in augmenting the angle of deflection as much as we please in the first part of the process, in which the deflection is produced by a weight. But in the second the case is different; and, with the slender needles here employed, a large deflection can only be attained by placing the deflecting needle at a very short distance from the moveable one. The most convenient arrangement appears to be to attach the former to the moveable arm of the divided circle which carries the verniers, and at right angles to the wires of the microscopes: so attached, it must always be rendered perpendicular to the deflected needle in the course of the observation, although in a different plane.

The quantity denoted by U, in this position, is a function of the distance of the centres of the two needles, and of the ratios of certain integrals which depend upon their magnetic distribution. It may be shown that the variations of these ratios, arising from the gradual changes of magnetism of the needles, may be disregarded; so that, if the distance be invariable, the function U will be constant. This is a point of considerable importance; for it follows from it that, even if the value of U be unknown, R will be relatively determined by a process which is *independent of the changes in the magnetic moments of the two needles*. Hence, if the value of the force be found at any one place, by any independent means, it will be absolutely known at all.

But the value of the constant U may be found by deflection, by the instrument itself, and the method therefore rendered rigorously *absolute*. In using the dip-circle for this purpose, it will be convenient to produce the equilibrium by turning the instrument in azimuth until the deflected needle is vertical; for, in this case, the deflecting magnet is always horizontal, and can be placed in the usual position with respect to the deflected magnet, without difficulty. For this purpose the apparatus is provided with a gun-metal bar, having a rectangular aperture, by means of which it passes over the box containing the deflected magnet, and rests on two supports fixed outside on the level of the agate planes. The deflecting magnet is to be placed on this support, at different known distances, and on each side of the deflected magnet, its axis being in the plane in which the latter moves; and the apparatus is to be turned in azimuth until the deflected needle is vertical. In this case equation (2) becomes

$$- X \cos a = MV;$$

in which V is of the form

$$V = \frac{2}{D^3}\left(1 + \frac{p}{D^2} + \frac{q}{D^4} + \&c. \right).$$

The quantities p and q are to be found in the usual manner, by repeating the observation at several known distances, and eliminating among the resulting equations. This being done, the deflecting magnet is to be removed from the bar, and placed in its ordinary position between the microscopes; and the observation is to be repeated. If a_0 denote the corresponding azimuth,

$$- X \cos a_0 = MU;$$

whence

$$U = V \frac{\cos a_0}{\cos a}.$$

The method here proposed appears to offer the following advantages to the travelling observer :—

1. It is applicable, with equal accuracy, at all parts of the globe.
2. It dispenses with the employment of a separate instrument for

the determination of the magnetic intensity, and with the separate adjustments required in erecting it.

3. The constants to be determined—the magnitude of the added weight, and the radius of the pulley by which it acts—can be ascertained with more ease and certainty than those which are required in the method of vibrations, and are less liable to subsequent change.

4. The observations themselves are less varied in character than the usual ones, and may be completed in a shorter time.

The Rev. Dr. Lloyd also read a paper—

ON AN IMPROVED FORM OF THE THEODOLITE MAGNETOMETER.

Dr. Lloyd exhibited to the Academy an improved form of the Theodolite Magnetometer, constructed under his direction by Mr. Jones of London, for the Magnetic Survey of the British Islands now in progress.

The principle of the improvement consists in observing the celestial object, whose azimuth is known, *by reflexion*, and in transferring the necessary adjustments to the small mirror used for that purpose. A light gun-metal frame, 13 inches long, and 3 inches wide, is attached to the upper plate of the theodolite. Near one end of this frame are two Y supports, placed longitudinally, to receive the observing telescope; and near the other are two similar supports, placed transversely, to receive the cylindrical axle to which the mirror is attached. The magnetometer box is placed between, over the centre of the divided circle. The telescope, accordingly, remains *horizontal*, and is always in adjustment for the observation of the collimator magnet; and the image of the celestial object is brought to the cross of wires in its focus, by turning the apparatus in azimuth, and, at the same time, causing the mirror to revolve. The axle is furnished with a slow motion for the purpose.

There are three adjustments required:—

1. The axle to which the mirror is attached must be horizontal when the instrument is levelled. This is tested by a small riding-level. It may be effected permanently, with sufficient exactness, by filing one of the Y's.

2. The *mirror* must be parallel to the axis of the cylindrical axle to which it is attached. This is tested by reversing the axle in its Y's, and by noting the reflected division of a scale cut by the wire in the focus of the telescope, before and after reversal. The adjustment is effected by means of three screws at the back of the mirror.

3. The line of collimation of the telescope must be perpendicular to the axis. This may be tested by observing a well-defined distant object in the horizon, first by reflexion, and afterwards directly; the deviation of the line of collimation from the normal to the mirror is half the supplement of the angle through which the telescope is moved. The adjustment may be most readily made by moving the wire-plate in the focus of the telescope.